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REPORT ON AN INVESTIGATION OF POLLUTION OF GROUND WATER IN THE GRANTS - BLUEWATER, NEW MEXICO AREA

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New Mexico Department of Public Health
Santa Fe, New Mexico

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REPORT ON AN INVESTIGATION OF POLLUTION OF GROUND WATER IN THE GRANTS-- BLUEWATER, NEW MEXICO, AREA

INTRODUCTION

The New Mexico Department of Public Health requested the assistance of the Public Health Service in an investigation of waste disposal at the uranium ore milling plant of the Anaconda Company at Bluewater, New Mexico. The investigation was undertaken because of concern over possible pollution of groundwater in the Grants-Bluewater area. The Health Department expressed particular concern over the possibility of excessive nitrates from the mill wastes polluting the wells that serve as the source of municipal water supply for Grants, New Mexico.

The initial field investigation was made during November 27 and 28, 1956. The following persons participated.

Robt. P. Lowe, Associate Engineer
New Mexico Department of Public Health
Santa Fe, New Mexico

Joe Anderson, Biologist
USPHS Region VII Office
Dallas, Texas

F. W. Kittrell, Public Health Engineer
Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

The Anaconda Company
Bluewater, New Mexico

A. Fitch, Manager
E. C. Peterson, Asst. Mgr.
R. D. Lynn, Plant Geologist
Jack Bee, Mill Foreman,
Carbonate Leaching Plant

Details of illustrations in this document may be better studied on microfiche.

In addition, the following were contacted at the Albuquerque Office of the U. S. Geological Survey, Ground Water Branch:

Clyde Conover, Chief
Ellis Gordon, Asst. Chief

This report summarizes activities and data available to date, and suggests the direction in which the investigation should continue.

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SOURCE OF WASTE

The uranium ore milling plant of The Anaconda Company is located about 1.5 miles southeast of Bluewater Station in Valencia County, New Mexico (Figure 1, Appendix). The plant is about 8.5 miles northwest of Grants, New Mexico.

This mill processes uranium ore to produce uranium concentrate, known as "yellow cake," for shipment to A.E.C. Two processes are used. Ore with high limestone content is concentrated by the carbonate leaching process. Ore low in limestone is concentrated by acid leaching followed by an ion exchange process known as the "resin-in-pulp" method.

Carbonate Leaching

Figure 2 is a simplified flow diagram of the carbonate leaching process. After grinding and classification the high limestone ore is leached at 250° F and 40 psi with a mixture of sodium carbonate and bicarbonate in the presence of manganese dioxide. Tails are separated from the leach liquor by filtration and sodium hydroxide is added to the liquor to precipitate uranium as the sodium salt. The tails are discharged as waste and the used leach solution is returned to the leaching system after reconversion of excess sodium hydroxide to sodium carbonate and bicarbonate by treatment with carbon dioxide.

Resin-in-Pulp Process

A simplified flow diagram of the resin-in-pulp process is shown in Figure 3. The low limestone ore is ground, classified, and leached with sulfuric acid in the presence of manganese dioxide. The leached material is classified into slimes (pulp) and sands. The sands are washed and classified for recovery of residual solutes and additional slimes, which are returned to the process. Tails from this procedure are discharged to waste. The pulp liquor, containing 6 to 10 per cent solids, passes through a number of ion exchange cells in series. The ion exchange resin is contained in baskets which are agitated in the flowing pulp stream to assure contact. When a basket of resin has absorbed the optimum amount of uranium it is removed from the circuit and eluted with a solution of ammonium nitrate in dilute sulfuric acid. The resulting solution of uranium salt (eluate) is classified to yield a sludge that is returned to leaching and a liquor from which uranium is precipitated by addition of magnesium hydroxide. The liquor is filtered to produce yellow cake and a filtrate which contains quantities of ammonium nitrate and sulfuric acid. After adjustment of the ammonium nitrate and sulfuric acid content of the

filtrate it is recirculated to the process (as eluant) for again eluting uranium from the ion exchange resin. The adjustment of chemical content of the eluant requires bleeding off a portion of the filtrate, which is discharged as waste.

Waste Characteristics

The wastes from the two processes are combined for discharge to a waste lagoon about one mile North of the plant.

The waste from carbonate leaching is alkaline and that from the resin-in-pulp is acid. Mixture of the two results in mutual neutralization to yield a pH near the neutral point of 7.0.

The combined waste flow from the two processes is estimated to be 3,000 gallons per minute (gpm) or 4.32 million gallons per day (mgd).

A single chemical analysis of the waste, taken from the lagoon on June 29, 1956, and analyzed by the New Mexico Department of Public Health laboratory, is available. Pertinent characteristics of the waste covered by the analysis are listed below.

Constituent	Parts per Million (ppm)	Pounds Per Day
Nitrates (N)	214(1)	7,720
Alkalinity ($CaCO_3$)	110	3,960
Chlorides (Cl)	84	3,030
Sodium (Na)	782	28,200
Calcium (Ca)	652	23,500
Sulfates (SO_4)	3,648	131,000
Magnesium (Mg)	166	5,980
Hardness ($CaCO_3$)	2,310	83,200

(1) Department of Public Health analysis showed 100 ppm, but Anaconda Company officials reported 214 ppm as better average value.

Waste Disposal

The waste is discharged to a lagoon which has no surface overflow. Its location in relation to the plant, to selected wells in the area, and to Grants is shown in Figure 1.

The water surface area in the lagoon was estimated by plant representatives to be 60 to 80 acres. No reliable estimate of depth was available, but it appears safe to assume that the average depth did not exceed 5 feet. Assuming a water surface area of 70 acres and an average depth of 5 feet the liquid storage in the lagoon at the time of the investigation would have been 350 acre feet. The waste flow of 4.32 mgd is equivalent to 6.7 cubic feet per second, or approximately 13.4 acre feet per day. The average daily waste discharge would equal the estimated 350 acre feet stored volume of waste in about 26 days.

Evaporation in this area exceeds rainfall by an average of about 3.5 feet per year, or an average 0.01 feet per day. Over a 70 acre water surface this would be equivalent to an evaporation rate of 0.7 acre feet per day or 5 per cent of the daily waste discharge rate.

The lagoon has been in use since the plant started operation in 1953. Company officials stated that the water level in the lagoon has been rising slowly during recent months. This statement agrees with information in a report to the State Engineer, dated July 5, 1956, by Zane Spiegel and S. E. Galloway, Geologists, New Mexico Water Resources and Development Section. This report was prepared following a visit by Messrs. Spiegel and Galloway, in company with Ellis Gordon, U. S. Geological Survey, to the Anaconda Plant during June 27 and 28, 1956. At that time the water surface area was estimated to be 30 to 40 acres. This would indicate that the surface area had approximately doubled in the 5 months between the end of June and the end of November 1956. If it be assumed that the increase in surface area to about 70 acres in November had been accompanied by an average 2 foot increase in depth since June the volume of stored waste has increased about 140 acre feet in 5 months. This estimated increase in storage is equivalent to the volume of waste discharged at the present rate in about 10 to 11 days.

While the foregoing values are approximations only, they probably are conservative and leave no doubt that most of the waste was percolating into the ground at the time of the November investigation. The estimated increase in storage of about one acre foot per day during the June-November period plus evaporation of 0.7 acre feet per day indicate that an estimated 11.7 acre feet per day of waste was escaping from the 70 acre waste lagoon by seepage. This would require a seepage rate of only 0.17 feet per day or 0.085 inches per hour, which is typical of fairly tight soils. It does not indicate that underground faults or fissures were involved to any significant extent in seepage of wastes from the lagoons.

Potential pollution of ground water of the area by the wastes thus definitely is a matter of concern.

During the November visit the Anaconda plant manager stated it was anticipated that slimes in the waste would seal the bottom of the lagoon, and ultimately all disposal of liquid waste would be by evaporation. He estimated this stage would be reached in about a year, at which time about a section of land would be required for lagoon area. The rate of observed increase in lagoon area during five months (June to November 1956), indicates that the estimate of one year for sealing the lagoon bottom by natural action of the waste slimes probably was optimistic. Computations based on the reported rate of waste discharge and local excess of evaporation over rainfall indicate that a minimum of at least two sections of lagoon area would be required during a year of average rainfall and evaporation. Even this would be inadequate in a year of high rainfall or low evaporation.

More recently a representative of the company has stated that research is under way to determine the feasibility of substituting sodium chloride for ammonium nitrate as the eluant in the ion-exchange process. It was reported that results of the research are promising. If this change should be adopted it should solve the problem of nitrate pollution of the ground water, but would not provide a complete solution of the ground water pollution problem. Presumably radioactivity, sulfates, chlorides, sodium, calcium, hardness and possibly magnesium would still pose a threat to quality of ground water in the area.

RESULTS OF INVESTIGATIONS

Previous Studies

Assays for Radioactivity

Before the Anaconda plant went into operation the New Mexico Department of Public Health recognized the possibility that the wastes might cause radioactive pollution of ground water. In 1953 the Department collected two series of samples from wells in the area before operations started at the Anaconda plant. These were examined for alpha and beta activity at the Robert A. Taft Sanitary Engineering Center. A third set samples was collected on November 8, 1955, about two years after the Anaconda plant went into operation. Examination of these samples did not reveal any significant increase in radioactivity at that time. Mineral analyses were not made on these samples.

Geological Investigation

As noted in a previous section, geologists of the New Mexico Water Resources and Development Section investigated the Anaconda Company waste lagoon and the surrounding area in June 1956. On the basis of geology of the area they concluded it appeared likely that disposal water from the Anaconda mill near Bluewater is moving downward and southward into the valley fill at the disposal site, thence moving radially away from the pond for some unknown distance, but moving generally down-valley to the southeast. This conclusion, if valid, would place the wastes in the shallow aquifer (valley fill) which serves as the source of the Grants municipal water supply, with movement generally towards the wells.

A diagrammatic sketch of a cross section of underground geology in the vicinity of the Anaconda plant was furnished by the plant geologist during the November visit. This sketch served as the basis for Figure 4. The original sketch was submitted to Messrs. Conover and Gordon of the Ground Water Branch, U. S. Geological Survey at Albuquerque for comment. They verified the general nature of the underground formations, but expressed the opinion that the waste lagoon lies directly over the fault, rather than to one side.

Current Studies

The New Mexico Department of Public Health collected samples for chemical analysis from wells in the Grants-Bluewater area during the November 1956 visit and again during March and May 1957. The results of analyses of the three sets of samples are given in Table 1 of the Appendix.

The Ground Water Branch, U. S. Geological Survey, at Albuquerque, has collected samples from wells in the area over a period of several years. This program is continuing. Results through August 1956 have been provided through the courtesy of the Ground Water Branch. Selected data from this course are shown in Table 2.

The Anaconda Company has maintained a well sampling program for some time. Data from this program are not available for the immediate purpose of this report.

Interpretation of Results

U. S. Geological Survey Data

The U. S. Geological Survey analytical data (Table 2) establish general chemical characteristics of well water in the San Andres formation of the Grants-Bluewater area before the Anaconda plant started operation.

Results in Table 2 are limited to these constituents that occur in both the wells and the Anaconda wastes. They include averages of values obtained on selected wells before 1955, when the "resin-in-pulp" process started operation, and individual values since that time.

Data on water from the shallow (Quartenary) aquifer were available on only 10 samples, of which five were from separate wells, three were from the sixth, and two were from the Grants well (well no. 11.10.26.411a). Only the latter are included in Table 2. The results of samples from the seven wells indicate that water quality in this aquifer varies widely. For example, among the seven wells, chlorides ranged between 8 and 9,590 ppm, hardness between 278 and 2,470 ppm, sulfates between 119 and 2,840, and nitrate N between 0.07 and 3.2 ppm. Obviously it is impossible to establish a common base of over-all water quality for this aquifer against which changes in the constituents typical of the Anaconda wastes can be judged.

Even in the Grants well there was a considerable variation in results on the two samples. Chlorides were 27 ppm in 1944 and 41 ppm in 1955, hardness 510 and 632 ppm, and sulfates 199 and 255 ppm. Although these constituents increased, nitrate N dropped slightly from 1.3 to 0.86 ppm.

Only prolonged and regular analysis could establish the normal characteristics, including ranges in concentrations, of any particular well in the shallow aquifer. Such data are not available.

The San Andres aquifer, on the other hand, tends toward a more nearly uniform water quality. There is a general trend of decreasing concentrations of constituents with distance, toward the southeast, from the Anaconda waste lagoon. This fact does not of itself duplicate the Anaconda waste, since the trend existed previous to 1955. While this trend is too definite to be questioned, there are exceptions to it. Some wells in the area are known to take water from both the Quartenary and the San Andres formations. Other wells in the San Andres formation are reported to have leaks at the Quartenary level which introduce water from the shallow aquifer. Either of these conditions might account for the few wells that do not follow the general trend of water quality in the San Andres aquifer.

The water of the San Andres aquifer is highly mineralized. The alkalinity generally is near 300 ppm, with a few values approaching 400 ppm. Sulfates are somewhat more variable, ranging from about 200 to as high as 400 ppm. Calcium around 100 to 150 ppm and magnesium around 30 to 50 ppm contribute to extremely hard water with a general range of 500 to 800 ppm, and an occasional value near 900 ppm.

Nitrate N before 1955 averaged generally between 1 and 7 ppm, with an occasional value outside this range. There was a general trend of decreasing nitrate with distance from the Anaconda waste lagoon. Nitrate N of wells within 1.7 miles of the plant averaged between 3.4 and 7.5 ppm before 1955. At distances of 3 miles or more it averaged between 1.2 and 4.8 ppm.

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Constituents, other than nitrates, sodium and chlorides, in a given well tend to be fairly consistent. Maximum variations of alkalinity, calcium, magnesium, hardness and sulfates in an individual well rarely exceed 20 per cent, and for many wells variations were only a few per cent. In only three wells were there fairly consistent increases in constituents typical of Anaconda wastes. Two of these wells (12.11.23.231 and 12.10.30.412) are within 2.4 miles of the waste lagoon. The third (11.10.9.221) is 5.6 miles distant. On the other hand a well (12.11.24.411) only 1.2 miles from the lagoon showed a decrease in these constituents.

It must be concluded that with the exception of nitrate results, there is little evidence in the U. S. Geological Survey data that positively indicates general contamination of the San Andres formation by Anaconda wastes.

Table 2 includes results on 10 wells in the San Andres formation which permit comparison of nitrate contents of well water before and since the resin-in-pulp process was started at the Anaconda plant. Of these six showed increases in the range of 0.3 to 9 ppm of nitrate N, with an average increase of 2.5 ppm. The six wells were between 1.2 and 5.6 miles from the Anaconda waste lagoon. Four of the wells showed decreases in the range of 0.3 to 1.6 ppm of nitrate N, with an average decrease of 1.1 ppm. These four wells were between 3.0 and 6.2 miles from the waste lagoon. Thus, in general, the wells closer to the waste lagoon tended to show increases in nitrates, while those more distant from the lagoon tended to show decreases. A few individual wells showed exceptions to this generalization. It is possible that reasons for the exceptions could be advanced if detailed information on soil conditions, and well depths, construction, operation and pumpage rates were available. The U. S. Geological data do indicate rather definitely that there is reason to suspect pollution of water in the San Andres formation by nitrates from the Anaconda wastes.

The well showing the greatest increase in nitrates is number 12.11.23.231, which is 1.5 miles from the Anaconda waste lagoon. Here nitrate N increased from an average of 7.5 ppm before 1955 to 17.2 and 16.9 ppm in June and July 1956. This well is an exception to the generalization that other constituents typical of the Anaconda wastes did not increase significantly in the San Andres wells. Here chlorides, sodium sulfates and hardness increased markedly. Alkalinity alone, of all comparable constituents, decreased slightly. The preponderance of evidence is that this well, close to the Anaconda plant, was receiving pollution from the Anaconda waste lagoon by June 1956.

Department of Public Health Data

All mineral analyses on well water in this area by the state health department laboratory have been made since the Anaconda plant started the resin-in-pulp process. These data (Table 1) do not permit comparison of water quality before and since the process went into operation. They do, however, permit determination of certain changes in water quality since

November 1956. They are more recent than the available U. S. Geological data, and indicate much more definitely the pollution of underground water by Anaconda wastes.

The wells in Table 1 have been divided into 2 groups. One group is the shallow wells which presumably take water from the Quartenary aquifer. The Grants wells take water from this formation. The other group is deep wells, presumably in the San Andres formation. In both groups the wells have been arranged in order of increasing distance from the Anaconda waste lagoon.

More emphasis has been placed on analysis for nitrates than for other constituents typical of Anaconda wastes. There are insufficient data on the other constituents to permit useful evaluation.

The nitrate data are shown graphically in Figure 5. They show a marked increase in nitrates in the ground water of the area during the six months between November 1956 and May 1957. All wells in the San Andres aquifer showed increases in nitrate N between November and May which ranged from 2.3 to 13.6 ppm. In terms of percentage the increases ranged from 77 to 275. These deep wells were within 2.4 miles of the Anaconda waste lagoon. In general, during May the nitrates in the San Andres wells decreased as distance from the lagoon increased. Well number 5, at 2.3 miles, was the only exception to this trend. In May all except one San Andres well yielded nitrates in excess of 10 ppm as N. In November 1956 the highest nitrate value found was 6.2 ppm. In May, about six months later, only one San Andres well had nitrates less than 6.2 ppm N. Four had nitrate N in the range of 15 to 19 ppm.

When the nitrate N in water used for drinking approaches 10 ppm it is cause for concern. Although there is definite proof that excessive nitrates cause methemoglobinemia in infants, the correlation of nitrate concentration with incidence of the disease is not exact. Some state health departments have established 10 ppm of nitrate N as the maximum permissible in drinking water, while others accept as much as 20 ppm.

The San Andres wells were approaching the maximum limit accepted as permissible in drinking water. The evidence points to the probability that even this extreme limit has, by now, been exceeded in some San Andres wells.

The changes in nitrates in the shallow wells were more erratic than those in the San Andres wells. Of six wells, two showed marked increases to 15 and 16 ppm N. One increased moderately to 4.3 ppm. Three had relatively insignificant changes. Of these, the Grants wells (sample number 8), the most distant from the Anaconda waste lagoon (9.1 miles), dropped from the March maximum of 0.8 ppm to 0.19 ppm N in May. The two wells with the maximum nitrates were among the three of the shallow wells closest (2.5 and 5.3 miles) to the waste lagoon.

It should be noted that the shallow well closest to the lagoon is farther from the lagoon than the farthest deep well sampled. It is probable that the shallow aquifer contained even higher nitrates at points near the waste lagoon.

The evidence strongly suggests that the Quartenary (shallow) aquifer, as well as the San Andres, is being polluted by nitrates in the Anaconda wastes. The increase in well number 10, 6.3 miles from the waste lagoon, indicates that the nitrate pollution has traveled to within 2.8 miles, and possibly less, of the Grants wells.

The evidence that nitrates in the Anaconda wastes have progressed farther in the underlying aquifers than have other constituents of the wastes is in agreement with findings elsewhere. This is accounted for by the selective nature of the ion exchange capacity of natural soils. The ion exchange capacity of natural soils for nitrates appears to be considerably less than it is for other inorganic constituents of the Anaconda wastes. Ultimately, as the natural ion exchange capacity of the soil in the two aquifers becomes exhausted, it is anticipated that other constituents of the wastes will show increases in the adjacent wells. There is evidence that this already has occurred in well number 12.11.23.231 (Table 2), 1.5 miles from the waste lagoon.

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SUMMARY AND CONCLUSIONS

1. The Anaconda Company uranium ore refining plant near Bluewater, New Mexico, produces a highly mineralized waste in concentrating uranium by the resin-in-pulp and the carbonate leaching processes.

2. The daily wastes contain about 3.9 tons of nitrate (as N), 66 tones of sulfates, 42 tons of hardness equivalent (as $CaCO_3$), 14 tons of sodium 12 tons of calcium, and lesser amounts of chlorides, alkalinity and magnesium in the range of [illegible] to 3 tons per day. Data are not available on daily quantities of radioactivity involved.

3. The combined wastes are discharged to a lagoon near the plant at a rate of about 13.4 acre feet per day. Estimates of rates of storage and evaporation account for only about 13 per cent of the waste discharged. It is concluded that about 87 per cent of the waste volume, with a like percentage of the soluble mineral constituents, was seeping underground between June and November 1956.

4. The estimated seepage (percolation) rate of 0.17 feet per day, or 0.085 inches per hour, is typical of rates found in fairly tight soils. This indicates that underground faults or fissures probably are not involved in seepage of wastes from the lagoon. Faults or fissures may be involved, however, in underground movement of the wastes.

5. The nitrates in the wastes derive from the resin-in-pulp process, which was started in 1955.

6. Since the resin-in-pulp process was placed in operation there have been increases in nitrate contents of water in wells drawing from both the Quartenary (shallow) and San Andres(deep) aquifers.

7. The rate of increase in nitrates in wells accelerated between March and May 1957.

8. Generally both the higher concentrations of and the greater increases in nitrates have tended to occur in wells nearer the waste lagoon than in those more distant from the lagoon.

9. In May 1957 two wells in the shallow aquifer and three in the deep aquifer had nitrate N in the range of 15 to 19 ppm. These values were approaching the maximum limit of 20 ppm nitrate N permissible in water used for drinking. It is possible that this limit has been exceeded in one or more of the wells since May.

10. Although nitrates generally tended to diminish as distance from the Anaconda lagoon increased, there was a moderate increase in nitrates in one shallow well as far as 6.3 miles from the lagoon. This well was only 2.8 miles from the Grants municipal water supply wells. The increase in nitrates here indicates the existence of an imminent threat to the Grant water supply.

11. There is only limited evidence that constituents other than nitrates in the Anaconda wastes had started to increase in the ground water of the area by May 1957. The limited data on water quality of wells in the shallow aquifer are too variable to permit conclusions regarding the other constituents. Increases in the other constituents in four wells in the deep aquifer may be significant. Well number 1 (Table 1) and wells number 11.10.9.221, 12.10.30.442, and 12.11.23.231 (Table 2) showed distinct increases in several constituents typical of the Anaconda wastes. Three of these wells were within 2.4 miles of the waste lagoon.

12. The selective nature of the ion exchange properties of natural soils probably accounts for the apparently limited penetration of other constituents of the Anaconda wastes in contrast to the definitely extensive penetration of the nitrates into the ground waters of the area. It has been found elsewhere that nitrate ions traveled both faster and farther in ground water than did the ions of other constituents. As the ion exchange capacities of the soils in the Grants-Bluewater area became exhausted by constituents of the Anaconda wastes it can be anticipated that there will be increases in radioactivity, sulfates, sodium, chlorides, calcium, magnesium and hardness as well as in nitrates in the ground waters of the area.

13. Some of the anomalous results probably could be explained if more complete information were available on soil conditions and well depths, construction, operation and pumpage. For example, nitrates might reach a distant well that was pumped heavily more quickly than they would a nearby well from which little water was drawn.

14. Recent reports indicate that the Anaconda Company may have abandoned earlier plans to dispose of all wastes by evaporation, and instead are planning on substitution of sodium chloride for ammonium nitrate in the resin-in-pulp process. While this would eliminate one of the health hazards inherent in the present method of waste disposal, it would leave unsolved the problem of ground water pollution by radioactivity and other waste constituents so long as the present disposal system is continued.

RECOMMENDATIONS

It is recommended that:

1. The Anaconda Company immediately take steps to prevent further nitrate pollution of ground water in the Grants-Bluewater, New Mexico area.

2. The Anaconda Company promptly initiate engineering studies to determine a practical method for preventing pollution of ground water by the radioactivity, sulfates, sodium, chlorides, calcium, magnesium, hardness, and other hazardous or harmful constituents of its wastes.

3. The Anaconda Company, pending a satisfactory solution of its waste disposal problem, institute a waste disposal monitoring system that will provide an accurate record of liquid volumes and quantities of constituents of their plant wastes that seep underground from their waste lagoon.

4. The Anaconda Company, under supervision of the New Mexico Department of Public Health, institute a regular program of ground water sampling and analysis in the Grants-Bluewater area, designed to determine further increases, if any, in pollution of the ground water and to trace the course of existing pollution. (A suggested plan of sampling and analysis is attached).

5. A plan, which can be put into effect rapidly if it should become necessary, be developed to provide an emergency source of supply or to remove nitrates from the present Grants supply in the event that excessive nitrates reach the city's wells.

APPENDIX

Suggested Program for Surveillance of Ground Water

I. Sample Wells

The wells below are suggested for routine sampling. Several factors entered into their selection. One was an attempt to choose wells somewhat uniformly spaced down the valley from the Anaconda waste lagoon, in both the Quartenary (shallow) and San Andres (deep) aquifers. Another was to use wells, where possible, for which there were previous analytical data.

Other factors may be more important than these and may dictate choice of alternate wells. Such factors as available pumping equipment, heavy pumpage, and use of water for drinking can only be determined locally, and may justify substitution of other wells for those suggested. The wells are designated by two systems of numbers, one used by the New Mexico Department of Public Health (D.P.H.) and the other by the U. S. Geological Survey (U.S.G.S.) Information available in this office at present is inadequate to permit correlation of one system with the other.

A. Quartenary wells

USGS	12.11.14.311
USGS	12.10.29.434
DPH	10
DPH	8
USGS	10.9.13.117

B. San Andres wells

DPH	1
DPH	11
DPH	5
USGS	11.10.5.212
USGS	11.10.16.121
USGS	11.10.21.242
USGS	10.10.3.400

There are several small springs in the vicinity of Horace Springs which are believed to be fed by the shallow aquifer. It is reported that a large spring, Ojo de Gallo, formerly issued from the San Andres formation, but in recent years has dried up because of excess pumpage from the San Andres aquifer. There may be no springs from this formation. If springs from either or both aquifers are used for drinking samples should be collected from at least one spring from each formation.

II. Sampling Schedule

All wells should be sampled for analysis at least once per month. If nitrates in well DPH 10 should be found to approach 10 ppm, the Grants wells (DPH 8) should be sampled more frequently, at least bimonthly and possibly weekly.

III. Sample Analyses

All samples should be analyzed for the following constituents:

Radium
Gross alpha activity
Gross beta activity
Nitrates (immediately after collection)
Ammonia (immediately after collection)
pH (at time of collection)
Alkalinity
Hardness
Calcium
Magnesium
Sodium
Chlorides
Any other significant constituents of Anaconda wastes.

IV. Additional Data

To assist in interpretation of the analytical data the following information, where available, should be assembled:

Type of well
Depth of well
Depth of casing
Depth of water intake point
Ground surface elevation, above sea level.
Static water level
Drawdown when pumping
Pumping rate
Average daily pumping time
Use of water
Log of soil formations

TABLE 1

RESULTS OF WELL WATER ANALYSES
GRANTS-BLUEWATER AREA, NEW MEXICO

Department of Public Health Data

Sample No.	Date Of Sampling	Depth Of Well in (Ft.)	Distance from Anaconda Waste Pond (Miles)	pH	Nitrates as N ppm	Alkalinity as $CaCO_3$ ppm	Chlorides as Cl ppm	Sodium as Na ppm	Calcium as Ca ppm	Sulfates SO_4 ppm	Magnesium as Mg. ppm	Hardness as $CaCO_3$ ppm
SHALLOW WELLS												
7	Nov. 56	139	2.5	7.70	2.76	230	27	40	97	202	39	402
	Mar. 57			-	3.86	-	26	-	-	193	-	-
	May 57			8.22	15							
9	Nov. 56	150	4.8	7.93	0.70	286	16	194	40	231	8	133
	Mar. 57			-	0.60	-	14	-	-	263	-	-
	May 57			8.36	0.61							
13	Nov. 56	Shallow	5.3	-	-	-	-	-	-	-	-	-
	Mar. 57			7.36	8.53	270	35	137	71	253	34	317
	May 57			7.76	16							
14	Nov. 56	Shallow	5.6	-	-	-	-	-	-	-	-	-
	Mar. 57			7.72	0.08	134	20	21	67	150	26	274
	May 57			7.57	0.46							
10	Nov. 56	109	6.3	7.36	1.54	228	39	44	145	293	33	498
	Mar. 57			-	2.91	-	38	-	-	263	-	-
	May 57			7.56	4.3							

TABLE 1 Continued

RESULTS OF WELL WATER ANALYSES
GRANTS-BLUEWATER AREA, NEW MEXICO

Department of Public Health Data

Sample No.	Date Of Sampling	Depth Of Well in (Ft.)	Distance from Anaconda Waste Pond (Miles)	pH	Nitrates as N ppm	Alkalinity as $CaCO_3$ ppm	Chlorides as Cl ppm	Sodium as Na ppm	Calcium as Ca ppm	Sulfates as SO_4 ppm	Magnesium as Mg. ppm	Hardness as $CaCO_3$ ppm
8 (Grants)	Nov. 56	110-95-85	9.1	7.46	0.58	296	59	77	135	288	43	514
	Mar. 57			-	0.80	-	55	-	-	270	-	-
	May 57			7.60	0.19		79					
DEEP WELLS												
12	Nov. 56	349	0.8	7.25	5.38	270	59	90	156	369	42	562
	Mar. 57			7.10	10.6	280	61	150	105	357	46	451
	May 57			7.51	19							
1	Nov. 56	389	1.0	7.10	5.60	274	64	99	160	398	45	584
	Mar. 57			7.10	14.0	280	63	107	165	420	52	626
	May 57			7.60	15.0							
11	Nov. 56	201	1.5	7.10	5.44	288	56	81	158	362	47	587
	Mar. 57			7.10	10.0	282	53	78	149	326	47	565
	May 57			7.78	15							
4	Nov. 56	280	1.6	7.84	6.20	206	24	20	95	127	28	352
	Mar. 57			-	11.1	-	26	-	-	135	-	-
	May 57			8.17	11							

TABLE 1 Continued

RESULTS OF WELL WATER ANALYSES
GRANTS-BLUEWATER AREA, NEW MEXICO

Department of Public Health Data

Sample No.	Date Of Sampling	Depth Of Well in (Ft.)	Distance from Anaconda Waste Pond (Miles)	pH	Nitrates as N ppm	Alkalinity as $CaCO_3$ ppm	Chlorides as Cl ppm	Sodium as Na ppm	Calcium as Ca ppm	Sulfates as SO_4 ppm	Magnesium as Mg. ppm	Hardness as $CaCO_3$ ppm
5	Nov. 56	Deep	2.3	7.72	4.80	266	25	9	139	159	29	466
	Mar. 57			-	4.92	-	24	-	-	150	-	-
	May 57			7.78	18							
6	Nov. 56	Deep	2.8	7.49	2.72	222	28	34	101	210	40	417
	Mar. 57			-	3.90	-	28	-	-	212	-	-
	May 57			8.06	5							
The Anaconda Co.		June 1956		7.0	214(1)	110	84	[illegible]	652	3,648	166	2,310
Waste Lagoon		May 1957		7.01	155							

(1) Average reported by the Anaconda Co.

TABLE 2

RESULTS OF WELL WATER ANALYSES
GRANT-BLUEWATER AREA, NEW MEXICO

U. S. Geological Survey Data

Well No.	Date Sampled	Dist. From Anaconda Waste Pond (Miles)	pH	Nitrates as N ppm	Alkalinity as $CaCO_3$ ppm	Chlorides as Cl ppm	Sodium as Na ppm	Calcium as Ca ppm	Sulfates as SO_4 ppm	Magnesium as Mg. ppm	Hardness as $CaCO_3$ ppm	Stratigraphic Unit
12.11.[illegible]411	Pre'55avg.	1.2	7.2	3.4	402	70	103	165	380	49	927	San Andres
	12-6-55		7.5	-	363	63	-	-	355	-	814	
	6-4-56		7.4	-	326	38	-	-	282	-	813	
	7-18-56		7.4	4.1	348	59	95	139	342	45	779	
12.11.23.231	Pre'55avg.	1.5	-	7.5	291	18	5.3	129	113	31	657	San Andres
	6-27-56		7.2	17.2	283	32	12	-	207	-	824	
	7-18-56		-	16.9	-	31	-	-	-	-	-	
12.11.25.214a	Pre'55avg.	1.7	-	6.5	362	56	95	147	256	49	836	San Andres
	7-18-56		7.4	9.0	338	55	88	145	365	52	875	
12.10.30.242	Pre'55avg.	2.3	-	-	366	22	-	-	-	-	-	San Andres
	6-28-56		7.5	5.9	325	24	18	-	178	-	670	
12.10.30.412	Pre'55avg.	2.4	-	6.5	338	39	18	144	280	58	742	San Andres
	8-10-55		7.3	-	342	38	-	-	270	-	792	
	6-5-56		7.6	-	354	65	-	-	394	-	920	
	7-18-56		7.5	6.8	330	39	55	-	304	-	762	
12.10.32.111	Pre'55avg.	3.0	-	4.8	308	32	50	126	268	42	721	San Andres
	6-15-55		7.3	5.0	295	30	-	-	-	-	798	
	7-18-56		7.5	3.2	281	23	41	-	295	-	754	

TABLE 2 Continued

RESULTS OF WELL WATER ANALYSES
GRANTS-BLUEWATER AREA, NEW MEXICO

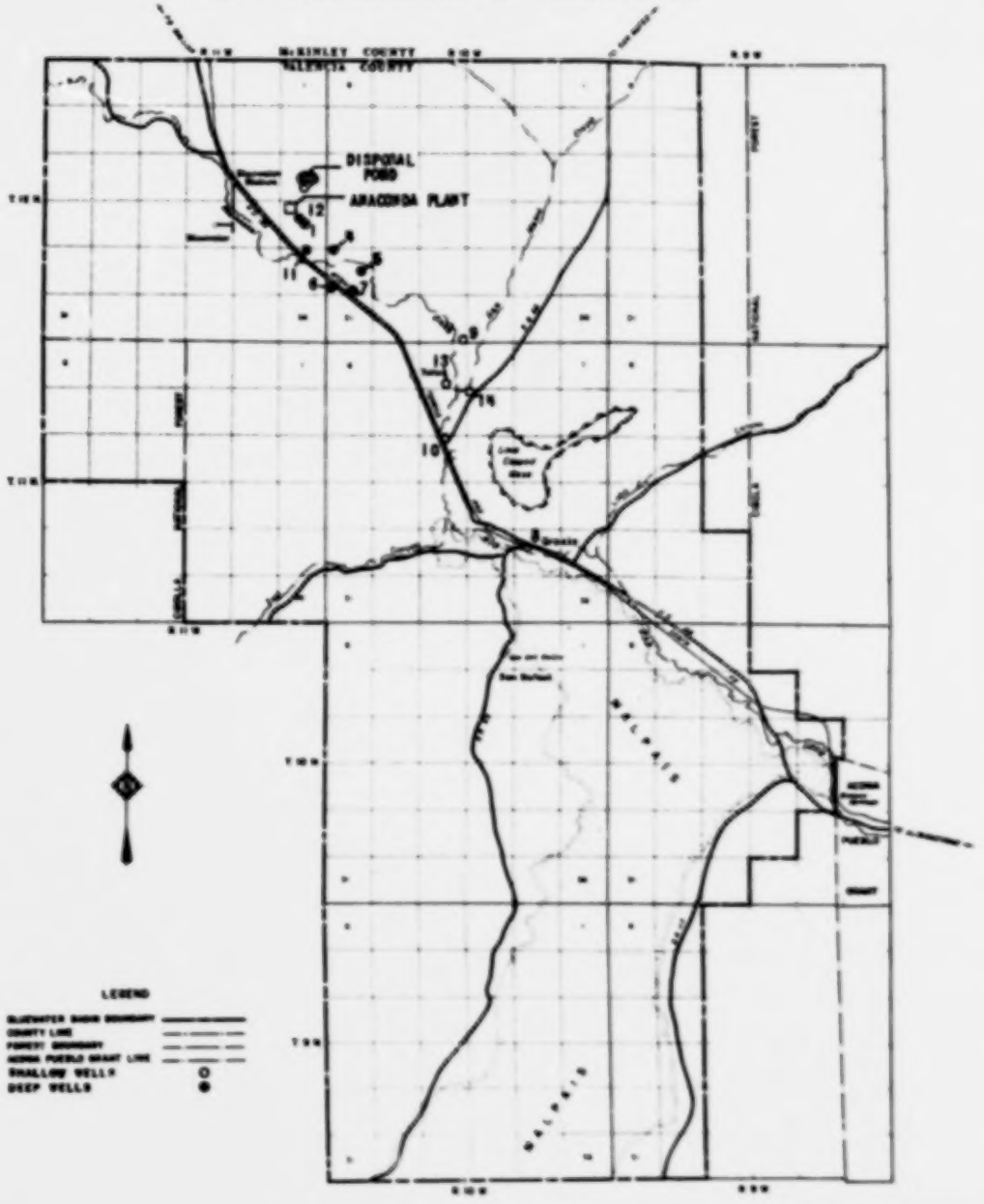
U. S. Geological Survey Data

Well No.	Date Sampled	Dist. From Anaconda Waste Pond (Miles)	pH	Nitrates as N ppm	Alkalinity as $CaCO_3$ ppm	Chlorides as Cl ppm	Sodium as Na ppm	Calcium as Ca ppm	Sulfates as SO_4 ppm	Magnesium as Mg. ppm	Hardness as $CaCO_3$ ppm	Stratigraphic Unit
12.11.20	Pre'55avg.	3.7	-	1.2	312	20	14	68	46	35	364	San Andres
	7-19-56		7.5	0.02	323	19	12	-	35	-	341	
12.10.27.333	Pre'55avg.	4.3	-	2.5	377	65	106	-	394	-	871	San Andres
	7-17-56		7.3	2.2	377	65	102	-	407	-	911	
11.10.4.211	Pre'55avg.	4.7	-	-	296	30	-	-	-	-	-	San Andres
	6-15-55		7.3	-	290	33	-	-	-	-	722	
	7-17-56		7.5	3.2	286	31	54	-	291	-	638	
11.10.8.221	Pre'55avg.	5.1	-	2.7	268	20	38	-	207	-	560	San Andres
	7-17-56		7.6	4.8	263	22	33	-	212	-	608	
11.10.9.221	Pre'55avg.	5.6	-	1.7	287	20	51	101	211	31	524	San Andres
	7-19-56		7.6	2.3	284	29	62	-	285	-	656	
11.10.16.121a	Pre'55avg.	6.2	-	4.1	273	21	50	112	224	30		San Andres
	7-17-56		7.6	2.9	266	18	35	-	191	-	534	
11.10.26.411a	Pre'55avg.	9.6	-	1.3	289	27	52	97	199	32	510	Quaternary
	6-15-55		7.4	0.86	328	41	67	118	255	38	632	

BLUEWATER UNDERGROUND WATER BASIN

May 21, 1956, Bluewater Underground Water Basin declared and closed to appropriations for irrigation, industrial, and municipal purposes.

WELL IDENTIFICATION NUMBERS
NEW MEXICO DEPARTMENT OF PUBLIC HEALTH



SCALE IN MILES

FIGURE 1

STATE OF NEW MEXICO
STATE ENGINEER OFFICE
BLUEWATER UNDERGROUND WATER BASIN

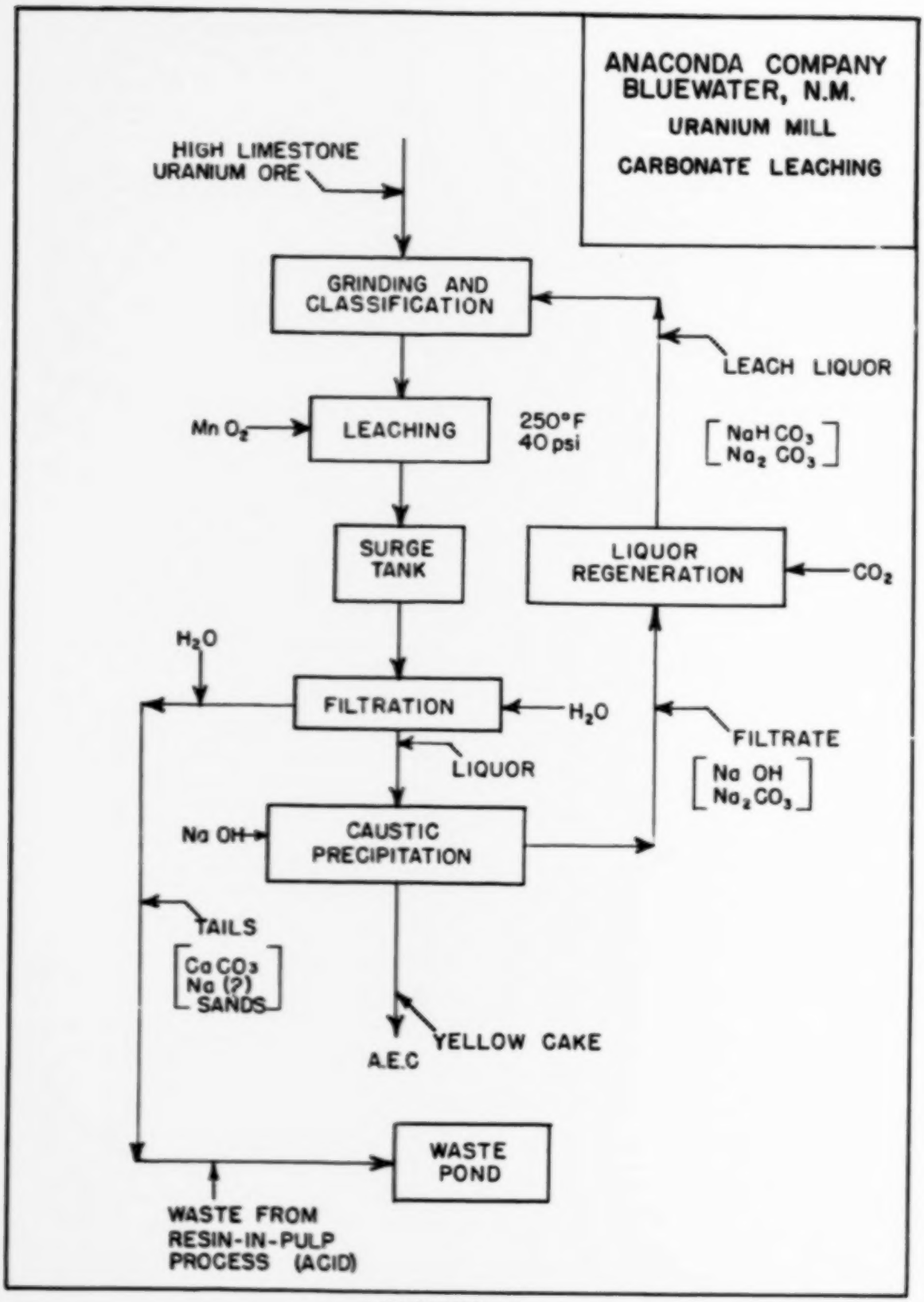

ANACONDA COMPANY
BLUEWATER, N.M.
URANIUM MILL
CARBONATE LEACHING
HIGH LIMESTONE URANIUM ORE
GRINDING AND CLASSIFICATION
LEACH LIQUOR
MnO_2
LEACHING
250°F
40 psi
$NaHCO_3$
Na_2CO_3
SURGE TANK
LIQUOR REGENERATION
CO_2
H_2O
FILTRATION
H_2O
FILTRATE
LIQUOR
NaOH
Na_2CO_3
NaOH
CAUSTIC PRECIPITATION
TAILS
$CaCO_3$
Na (?)
SANDS
YELLOW CAKE
A.E.C
WASTE POND
WASTE FROM RESIN-IN-PULP PROCESS (ACID)

FIGURE 2

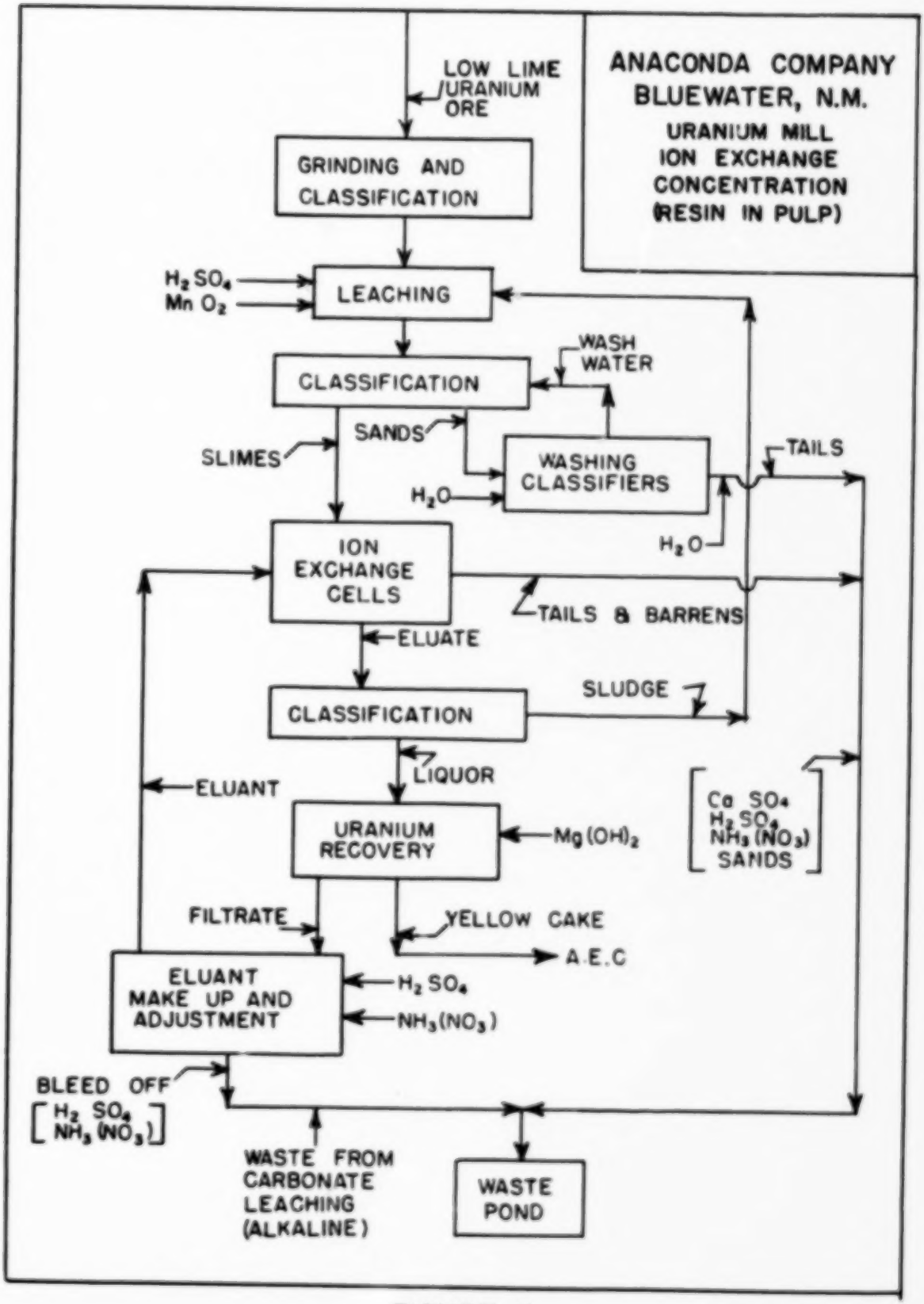
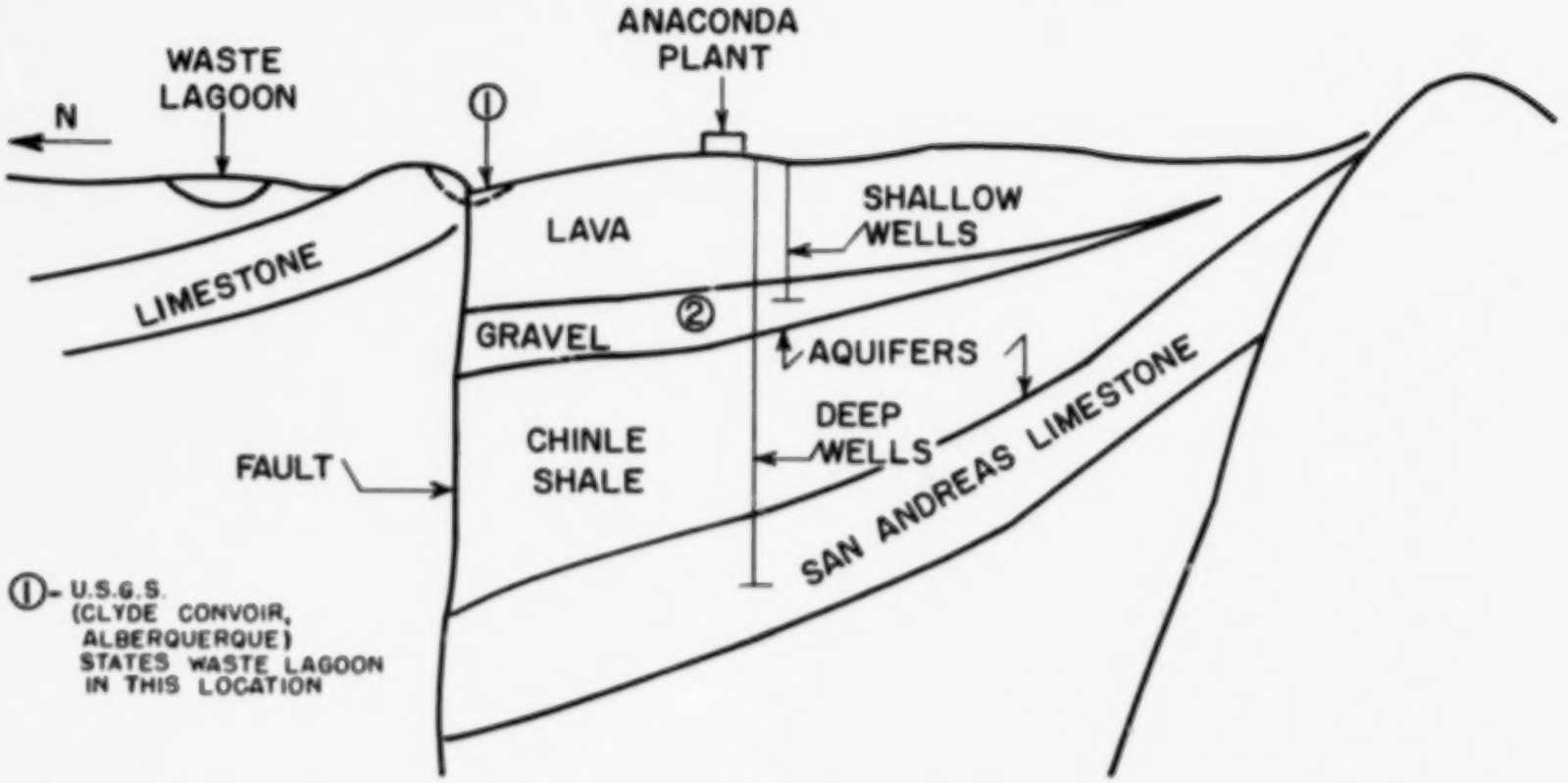

ANACONDA COMPANY
BLUEWATER, N.M.
URANIUM MILL
ION EXCHANGE
CONCENTRATION
(RESIN IN PULP)
LOW LIME URANIUM ORE
GRINDING AND CLASSIFICATION
H_2SO_4
MnO_2
LEACHING
WASH WATER
CLASSIFICATION
SANDS
SLIMES
WASHING CLASSIFIERS
TAILS
H_2O
H_2O
ION EXCHANGE CELLS
TAILS & BARRENS
ELUATE
SLUDGE
CLASSIFICATION
LIQUOR
ELUANT
URANIUM RECOVERY
$Mg(OH)_2$
$CaSO_4$
H_2SO_4
$NH_3(NO_3)$
SANDS
FILTRATE
YELLOW CAKE
A.E.C
ELUANT MAKE UP AND ADJUSTMENT
H_2SO_4
$NH_3(NO_3)$
BLEED OFF
H_2SO_4
$NH_3(NO_3)$
WASTE FROM CARBONATE LEACHING (ALKALINE)
WASTE POND

FIGURE 3



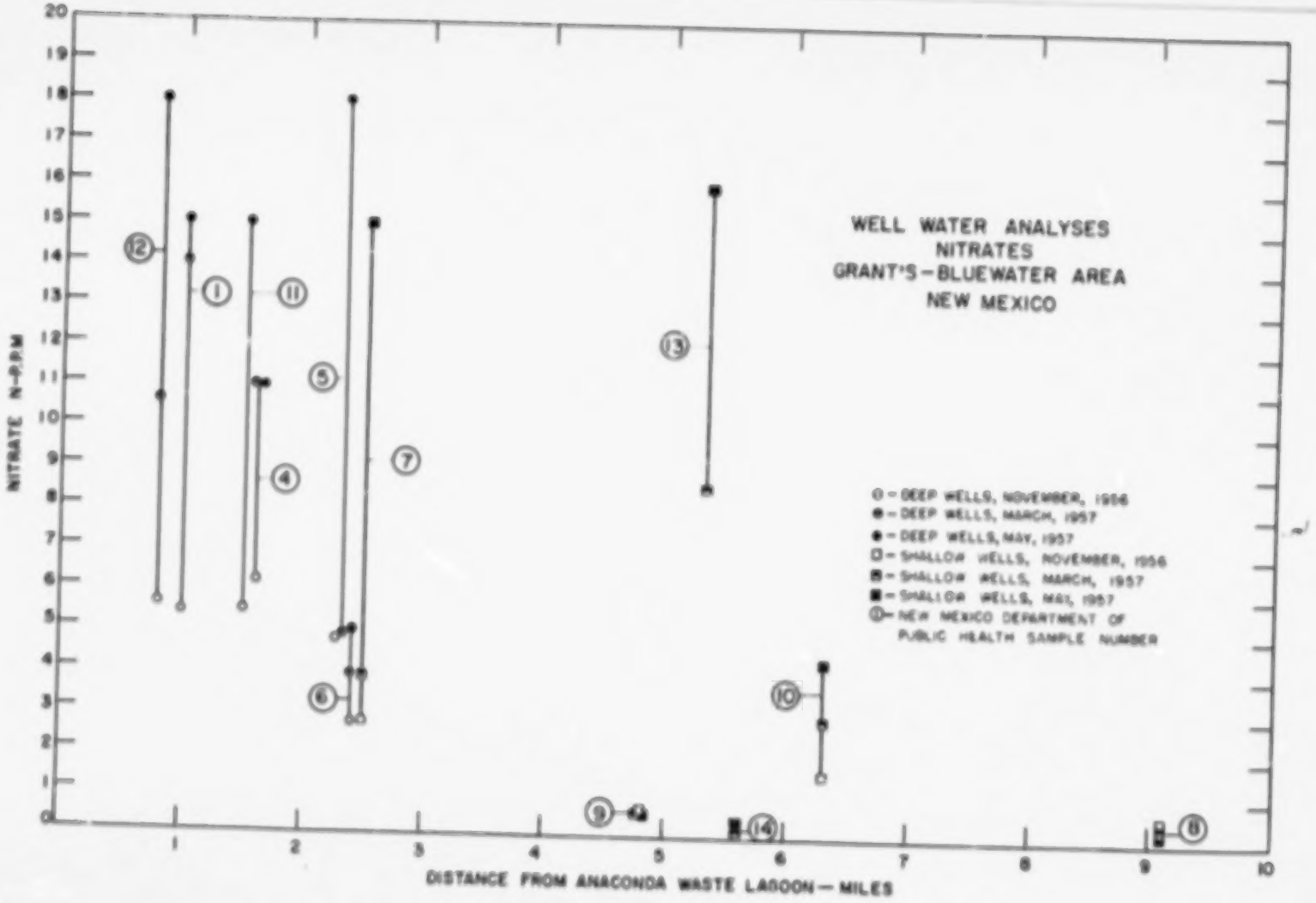
① - U.S.G.S. (CLYDE CONVOIR, ALBERQUERQUE) STATES WASTE LAGOON IN THIS LOCATION

② - THIS AQUIFER SOURCE FOR GRANTS, NEW MEXICO PUBLIC WATER SUPPLY. ABOUT 9 MILES SOUTH-EAST OF WASTE LAGOON.

ANACONDA COMPANY
BLUEWATER, NEW MEXICO

APPROXIMATE GEOLOGY IN VICINITY OF PLANT
(AFTER R.D. LYNN, PLANT GEOLOGIST)

FIGURE 4


WELL WATER ANALYSES
NITRATES
GRANT'S-BLUEWATER AREA
NEW MEXICO
O - DEEP WELLS, NOVEMBER, 1956
● - DEEP WELLS, MARCH, 1957
● - DEEP WELLS, MAY, 1957
□ - SHALLOW WELLS, NOVEMBER, 1956
▣ - SHALLOW WELLS, MARCH, 1957
■ - SHALLOW WELLS, MAY, 1957
① - NEW MEXICO DEPARTMENT OF PUBLIC HEALTH SAMPLE NUMBER
NITRATE N-P.P.M
DISTANCE FROM ANACONDA WASTE LAGOON - MILES

WELL WATER ANALYSES
NITRATES
GRANT'S-BLUEWATER AREA, NEW MEXICO

FIGURE 5